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## (54) Communication Equipment with Transmission Rate Regulating Function

(57) An RSSI detector detects the level of the electric field of a received signal, and an initial value of the transmission rate is determined from the detected level of the received electric field. A radio circuit transmits the determined initial value to a base station and in response the base station transmits a control signal at the assigned initial value of the transmission rate. A bit error rate detector detects the bit error rate of the control signal and the initial value of the transmission rate is fine regulated according to the detected bit error rate in order to determine an optimal transmission rate.

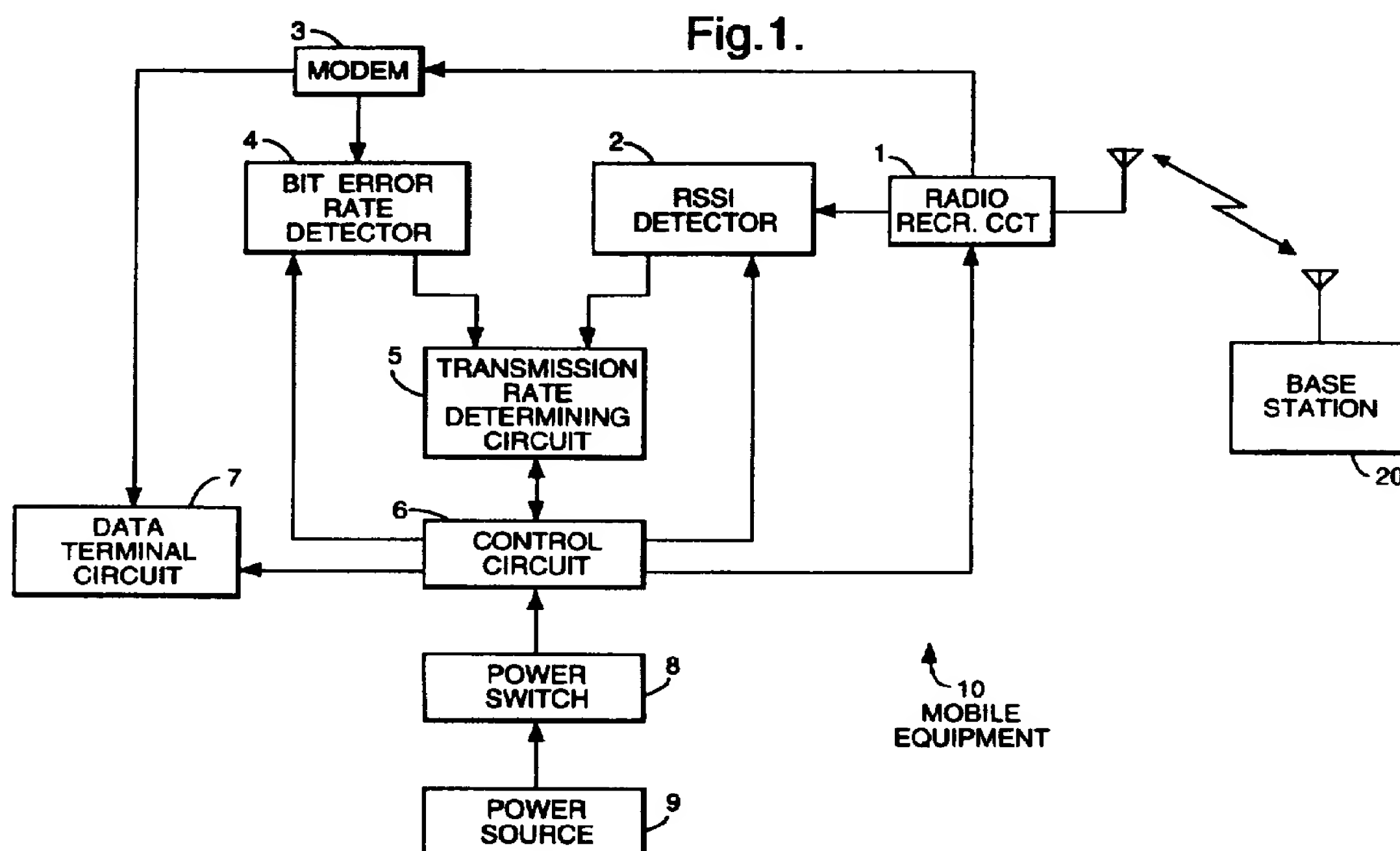


Fig.1.

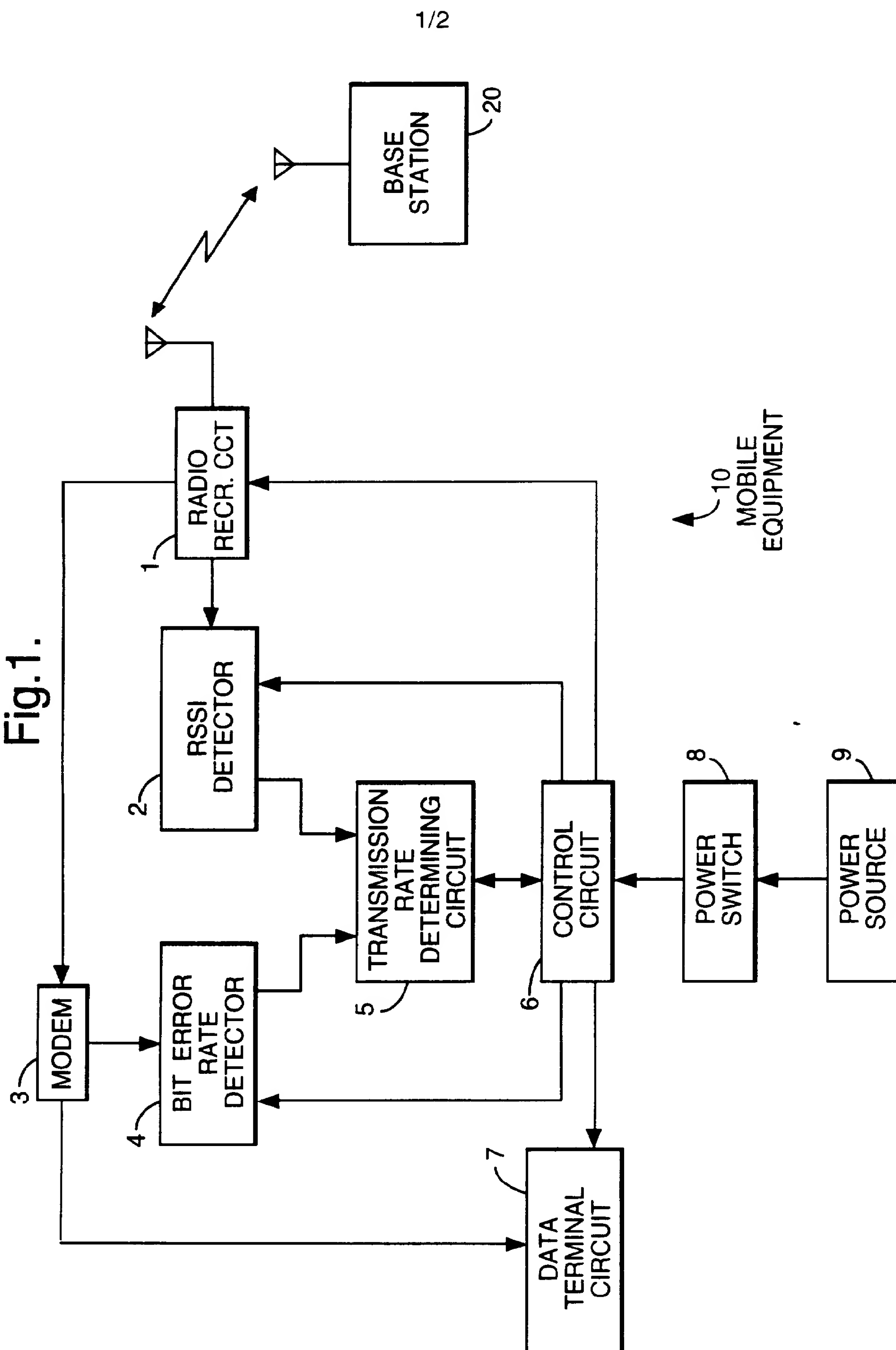


Fig.2.

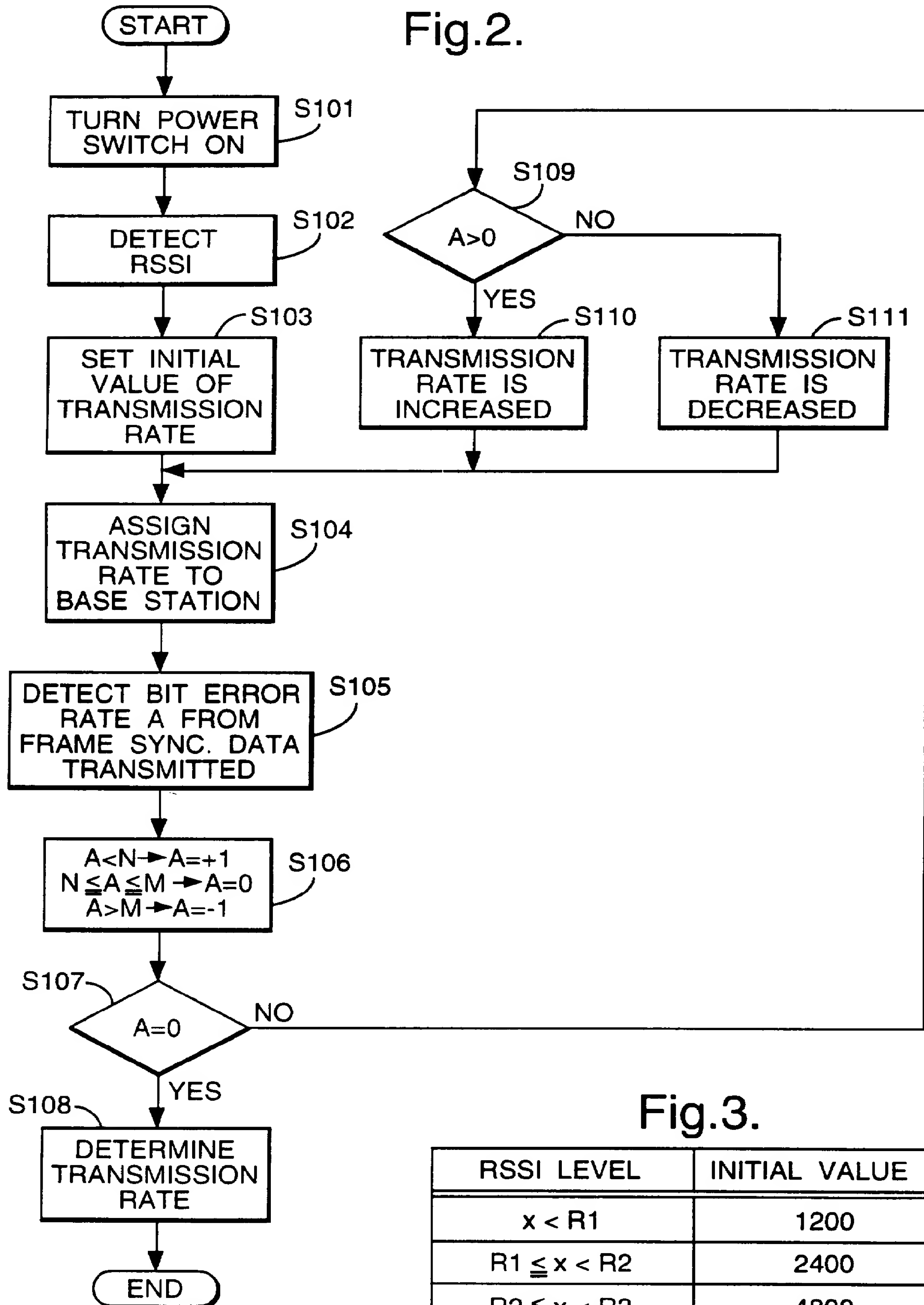


Fig.3.

RSSI LEVEL	INITIAL VALUE B
$x < R1$	1200
$R1 \leq x < R2$	2400
$R2 \leq x < R3$	4800
$R3 \leq x$	9600

COMMUNICATION EQUIPMENT WITH TRANSMISSION RATE  
REGULATING FUNCTION AND METHOD OF OPERATION

The present invention relates to communication equipment with a transmission rate regulating function, particularly, though not exclusively, to radio communication equipment with a transmission rate  
5 regulating function, and to a method of operation thereof.

Private communication equipment, such as a portable telephone set and a peripheral device therefor, tend to be made compact in order to improve their portability,  
10 and to make it possible to communicate, even when a user of the communication equipment is moving at high speed on a vehicle, such as a car or a train.

In the case in which communication is made via communication equipment which is moving at a high speed,  
15 however, the effect of fading becomes considerable, and the level of variation in the electric field is considerable. Therefore, there is an increase in the transmission error rate, and data transmission becomes difficult.

20 With facsimile equipment that uses a radio channel, it is possible to change the transmission rate of a data signal according to the level of the received electro-

magnetic wave coming from the other end of the communication link in such a way that, when the receiving level is changed, the transmission rate is lowered from the initial value of the transmission rate, which is set at the maximum transmission rate. Such facsimile equipment is disclosed in, for example, Japanese Patent Application Laid-open No. H4-90664 (JP-A-4-90664). On the other hand, with facsimile equipment which uses transmission via a cable, an optimal transmission rate is determined by calculating the S/N ratio of a channel, on the basis of a received signal level for checking the channel quality and the noise level during a non-signal period. Such cable facsimile equipment is disclosed in, for example, Japanese Patent Application Laid-open No. S61-218269 (JP-A-61-218269).

However, in the above-mentioned prior art in which a received electric field level is detected, a data error may occur due to the influence of fading. Further, in the above-mentioned prior art in which the S/N ratio is calculated, the reference value for the received signal level is liable to become unstable due to the influence of fading on the transmission channel.

Features of an arrangement illustrative of the invention and to be described below, by way of example, are that radio communication equipment is improved by the provision of a transmission rate regulating function, and

by the provision of such a function which includes the detection of an optimal transmission rate on the basis of  
5 the field strength of a received electric signal and a bit error rate.

In a particular arrangement illustrative of the present invention, and to be described below, by way of example, a communication equipment with a transmission  
10 rate regulating function includes a detector for detecting the electric field level of a signal received from another communication station, a transmission rate determining circuit for assigning a transmission rate to a control signal from the other station according to the  
15 received electric field level detected by the detector, a control circuit and a bit error rate detector for detecting a bit error rate, wherein the transmission rate determining circuit determines an optimal transmission rate by regulating the assigned transmission rate  
20 according to the bit error rate detected by the bit error detector.

In one arrangement the control circuit assigns the transmission rate determined by the transmission rate determining circuit to the other station.

25 In a particular arrangement the detector determines the receiving electric field level on the basis of a voltage value of the received signal.

In another arrangement the bit error rate detector portion detects the bit error rate by using the frame  
5 sync data of the control signal.

In yet another arrangement to be described below, by way of example and illustrative of the invention, a communication equipment with a transmission rate regulating function includes a receiving circuit for  
10 receiving a signal from another communication station, a level detector for a received electric field for detecting the level of the electric field of the signal received by the receiving circuit, a bit error rate detector for detecting a bit error rate of the signal  
15 received by the receiving circuit and a transmission rate determining circuit for setting an initial value of the transmission rate according to the received electric field level detected by the received electric field level detector and determining an optimal transmission rate by  
20 regulating the initial value according to the bit error rate detected by the bit error rate detector.

In one arrangement the bit error rate detector detects a bit error rate from a signal received after the initial value of the transmission rate is determined by  
25 the transmission rate determining portion.

Further, in another arrangement the communication equipment includes a data terminal circuit which has a user interface function and manages data storage, and

a modem for modulating and demodulating data in communication with the other station.

5        There will also be described below, in illustration of another aspect of the present invention, a control method for regulating the signal transmission rate of a communication equipment, which includes the steps of detecting a received electric field level of a signal  
10    from another station, assigning the transmission rate of a control signal from the other station according to the detected received electric field level, detecting the bit error rate of the control signal and determining an optimal transmission rate by regulating the assigned  
15    transmission rate, according to the detected bit error rate.

      In yet a further aspect of the present invention to be described below, by way of example, a control method for regulating the signal transmission rate of a  
20    communication equipment includes the steps of receiving a signal from another station, detecting the electric field level of the received signal, setting an initial value of the transmission rate, according to the detected received electric field level, and determining an optimal  
25    transmission rate by regulating the initial value, according to the detected bit error rate.

      Arrangements, illustrative of the present invention, will now be described, by way of example, with reference



to the accompanying drawings in which:

Fig. 1 is a block schematic circuit diagram,

5 Fig. 2 is a flow chart for use in illustrating the operation of the embodiment shown in Fig. 1, and

Fig. 3 is a table showing the relation between a received electric field level and a transmission rate.

10 In Fig. 1, a mobile radio communication equipment 10 has a radio receiver circuit 1, an RSSI (Received Signal Strength Indication) level detector 2, a modem 3, a bit error rate detector 4, a transmission rate determining circuit 5, a control circuit 6, a data terminal circuit 7, a power switch 8, and a power source 9.

15 The radio circuit 1 of the mobile radio communication equipment 10 has an interface function for an infra radio station and transmits/receives a signal to/from a base station 20. The RSSI level detector 2 receives a radio signal transmitted continuously by the base station 20 and received by the radio circuit 1, and  
20 detects the level of the electric field of the received radio signal. The received electric field level thus detected is converted into a voltage value and an RSSI level, which becomes a reference for an initial value of  
25 the transmission rate which is detected.

The modem 3 modulates and demodulates the communication data. The bit error rate detector 4 detects the bit error rate for finely regulating the

transmission rate, on the basis of frame sync data from the modem 3. The frame sync data is inserted into and  
5 around a header portion of a control signal from the base station 20.

The transmission rate determining circuit 5 sets the initial value of the transmission rate on the basis of the RSSI level from the RSSI level detector 2, and  
10 determines the optical transmission rate by finely regulating the initial value on the basis of the bit error rate from the bit error rate detector 4. The control circuit 6 controls the operation of various circuit portions of the mobile radio communication  
15 equipment 10. The data terminal circuit 7 has a user interface function and manages data storage. The power switch 8 is adapted to be manually operated, on/off, by a user to connect and disconnect the power source 9 to the various circuit portions.

20 Now, the operation of the mobile radio communication equipment 10 shown in Fig. 1 will be described with reference to the flowchart shown in Fig. 2.

The control circuit 6 detects when the power switch 8 is turned on (step S101), and supplies the power source  
25 voltage to the radio portion 1. In response thereto, a receiving circuit of the radio circuit 1 starts to receive a radio signal which has a predetermined frequency and is transmitted continuously at a

predetermined transmission rate by the base station 20.  
The RSSI level detector 2 detects the level of the  
5 received electric field of the radio signal received by  
the radio circuit 1 and detects the RSSI level by  
converting the received electric field level into a  
voltage value (step S102). The transmission rate  
determining circuit 5 determines an initial value B of  
10 the data transmission rate on the basis of the RSSI from  
the RSSI level detector 2 (step S103).

Fig. 3 shows a preferred relation between the RSSI  
level and the initial value B of the transmission rate.  
In Fig. 3, the detected RSSI level x is compared with  
15 predetermined RSSI levels R1, R2 and R3, respectively,  
where  $R1 < R2 < R3$ . When the detected RSSI level x is  
lower than the predetermined first value R1, the initial  
value B of the transmission rate is set to 1200 bps.  
When the detected RSSI level x is not lower than the  
20 predetermined second value R2, but it is lower than the  
third value R3, the initial value B is set to 4800 bps.  
When the detected RSSI level x is not lower than the  
third value R3, the initial value B of transmission rate  
is set to 9600 bps.

25 The control circuit 6 responds to the initial value  
B of the transmission rate determined in the step S103 to  
request the radio circuit 1 to transmit a transmission  
rate assigning signal to the base station 20. The radio

circuit 1 transmits the transmission rate assigning  
signal instructing communication to take place at the  
5 initial value B of transmission rate to the base station  
20, upon the request from the control circuit 6 (step  
S104). When, for example, the detected RSSI level x is  
lower than the first level R1, the transmission rate  
assigning signal instructing transmission to take place  
10 at the initial value 9600 bps is sent to the base station  
20.

In response to the transmission rate assigning  
signal, the base station 20 sends the control signal,  
including the frame sync data, to the mobile radio  
15 communication equipment 10. The frame sync data received  
by the radio circuit 1 is supplied through the modem 3 to  
the bit error rate detector 4. The bit error rate  
detector 4 detects a bit error rate A of the frame sync  
data (step S105) and ranks the detected bit error rate  
20 (step S106).

The detected bit error rate y is compared with  
predetermined first and second threshold values N and M,  
respectively, where  $N < M$ ). It is preferable that the  
bit error rate is of the order of 1%. For example, the  
25 threshold values N and M are 0.5% and 1.2%, respectively.  
When the detected bit error rate y is smaller than the  
first threshold value  $N = 0.5\%$ , the bit error rate A is  
ranked as "+1". When the detected bit error rate y is

not smaller than the first threshold value  $N = 0.5\%$  and is not larger than the second threshold value  $M = 1.2\%$ ,  
5 the bit error rate A is ranked as "0". When the detected bit error rate y is larger than the second threshold value  $M = 1.2\%$ , the bit error rate A is ranked as "-1".

When the rank of the bit error rate A is 0 after the ranking operation in the step S106 (YES in step S107), it  
10 is determined that the initially set transmission rate is appropriate and the transmission of data is started at the initial value B of the transmission rate (step S108).

When the rank in the step S107 is not 0 (NO in step S107), it is determined whether the rank is larger than 0  
15 (step S109). That is, when the transmission rate is not appropriate, it is determined whether the transmission rate is higher or lower than the appropriate value. When the rank is larger than 0, that is, the transmission rate is determined as lower, the transmission rate is  
20 increased and a new transmission rate is set (step S110). On the other hand, when it is determined that the rank is smaller than 0, that is the transmission rate is higher, the transmission rate is decreased and another new transmission rate is newly set (step S111).

25 For example, when the initial transmission rate is 4800 bps and the bit error rate A is ranked as "H", a new transmission rate 9600 bps is set. On the other hand, when the initial transmission rate is 4800 bps and the

bit error rate A is ranked as "-1", a new transmission rate 2400 bps is set.

5        When such a new transmission rate is set, the control circuit 6 controls the radio circuit 1 to send a signal assigning the newly set transmission rate to the base station 20. In response to the signal, the base station 20 sends the control signal at the newly set  
10       transmission rate. The processing operation from the step S104 to the step S111 is repeated until the transmission rate becomes appropriate.

As explained above, with the arrangement described, it is possible to determine quickly the optimal  
15       transmission rate by assigning a desired transmission rate to the base station after the initial value of the transmission rate has been set by detecting the level of the received electric field, and controlling the transmission rate optimally, on the basis of the bit  
20       error rate of the control signal from the base station. Therefore, it becomes possible to improve the efficiency of information management.

While the present invention has been illustrated, by way of example, with reference to a specific embodiment  
25       thereof, it will be appreciated that variations and modifications thereof, as well as other embodiments are possible within the scope of the protection sought by the appended claims.

**CLAIMS**

5           1.    Communication equipment with a transmission  
rate regulating function, including

          a level detector for detecting the level of the  
electric field of a received radio signal transmitted  
from another station,

10           first assigning means for assigning a transmission  
rate to a control signal to be transmitted from the other  
station, according to the level of the electric field of  
the received signal detected by the level detector,

          means for detecting the bit error rate of a control  
15   signal transmitted from the other station, and means for  
determining an optimal transmission rate by regulating an  
assigned transmission rate according to the detected bit  
error rate.

20           2.    Communication equipment as claimed in claim 1,  
including second assigning means for assigning an optimal  
transmission rate, determined by the determining means,  
to the other station.

25           3.    Communication equipment as claimed in claim 1,  
wherein the first assigning means determines the  
receiving electric field level on the basis of a voltage  
value of the received signal.

4. Communication equipment as claimed in claim 1,  
wherein the bit error rate detector detects the bit error  
5 rate by using the frame sync data of the control signal.

5. A radio communication equipment with a  
transmission rate regulating function, including  
receiving means for receiving a signal from another  
10 station,

first detection means for detecting the level of the  
electric field of the signal received by the receiving  
means,

second detection means for detecting the bit error  
15 rate of the signal received by the receiving means, and  
transmission rate determining means for setting an  
initial value of the transmission rate according to the  
level of the received electric field detected by the  
first detection means and for determining a more  
20 preferable transmission rate by regulating the initial  
value of the transmission rate according to the bit error  
rate detected by the second detection means.

6. A radio communication equipment as claimed in  
25 claim 5, including means for assigning the initial value  
of the transmission rate and the more preferable  
transmission rate to the other station.



7. A radio communication equipment as claimed in  
5 claim 6, wherein the second detection means detects the  
bit error rate from a signal received after the assigning  
means has assigned the initial value of the transmission  
rate.

10 8. A radio communication equipment as claimed in  
claim 5, wherein the level of the received electric field  
is detected as a voltage value.

9. A radio communication equipment as claimed in  
15 claim 5, including

a data terminal portion having a user interface  
function and managing a storage of data, and

a modem portion for modulating and demodulating  
communication data transmitted to and from the other  
20 station.

10. A control method for regulating the signal  
transmission rate of a communication equipment, including  
the steps of

25 detecting the level of the electric field of a radio  
signal received from another station,

assigning a transmission rate to a control signal  
from the other station according to the level of the

received electric field detected in the detecting step,  
detecting the bit error rate of the control signal  
5 transmitted from the other station, and  
determining a more preferable transmission rate by  
regulating the assigned transmission rate according to  
the detected bit error rate.

10 11. A control method as claimed in claim 10,  
including the step of assigning the determined more  
preferable transmission rate to the other station.

12. A control method as claimed in claim 10,  
15 wherein the bit error rate is detected from the frame  
sync data of the control signal.

13. A control method for regulating the signal  
transmission rate of a radio communication equipment,  
20 including the steps of  
receiving a signal transmitted from another station,  
detecting the level of the electric field of the  
received signal,  
detecting the bit error rate of the received signal,  
25 and  
setting an initial value of the transmission rate  
according to the detected received electric field level  
and determining a more preferable transmission rate by

regulating the initial value of transmission rate  
according to the detected bit error rate.

5

14. Communication equipment as claimed in either  
claim 1 or claim 5 substantially as described herein with  
reference to Figs. 1 and 2 of the accompanying drawings.

10

15. A control method as claimed in either claim 10  
or claim 13 substantially as described herein with  
reference to the accompanying drawings.



Application No: GB 9615688.0  
Claims searched: all

Examiner: Nigel Hall  
Date of search: 6 November 1996

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.O): H4L (LDG); H4P (PAQ)

Int CI (Ed.6): H04L 1/12 ; H04B 7/005

Other: Online: WPI

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0565230 A2 (IBM)	
A	WO 92/22162 A1 (BRITISH TELECOM)	

X Document indicating lack of novelty or inventive step  
Y Document indicating lack of inventive step if combined with one or more other documents of same category.

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A Document indicating technological background and/or state of the art.  
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